

We Claim:

1. A composite core for an aluminum conductor composite core reinforced cable comprising:
  - 5 two or more longitudinally oriented and substantially continuous reinforced fiber types in a thermosetting resin matrix, said core having at least 50% fiber volume fraction and an operating capability in the range of about 90 to about 230 °C.
  - 10 2. A composite core as set forth in claim 1 wherein the reinforced fiber types of the composite core are selected from the group consisting of carbon, Kevlar, basalt, glass, aramid, boron, liquid crystal fibers, high performance polyethylene and carbon nanofibers.
  - 15 3. A composite core as set forth in claim 1 comprising a thermosetting resin having a neat resin fracture toughness at least about 0.87 INS-lb/in.
  4. A composite core as set forth in claim 1 comprising a thermosetting resin having a tensile strength at least about 160 to about 240 Ksi.
  - 20 5. A composite core as set forth in claim 1 comprising a thermosetting resin having the ability to withstand operating temperatures in the range of about 90 to about 230 °C.
  - 25 6. A composite core as set forth in claim 1 wherein at least one reinforced fiber type comprises a modulus of elasticity in the range of about 22 to 37 Msi coupled with a coefficient of thermal expansion in the range of about -0.7 to about 0 m/m/C.
  - 30 7. A composite core as set forth in claim 1 wherein at least one reinforced fiber type comprises a modulus of elasticity in the range of about 6 to about 7 Msi coupled with a coefficient of thermal expansion in the range of about  $5 \times 10^{-6}$  to about  $10 \times 10^{-6}$  m/m/C.

8. A composite core as set forth in claim 1 comprising a fiber/resin volume fraction in the range of about 50 to about 57%.
- 5 9. A composite core as set forth in claim 1 comprising a fiber/resin ratio in the range of about 62 to about 75% by weight.
- 10 10. A composite core as set forth in claim 1 comprising an ambient temperature capability in the range of about -40 to about 90 C.
- 10 11. A composite core as set forth in claim 1 wherein said composite core comprises a hybridized concentric core having an inner carbon/epoxy layer and an outer glass fiber/epoxy layer.
- 15 12. A composite core for an aluminum conductor composite core reinforced cable comprising:
- 20 at least one longitudinally oriented and substantially continuous reinforced fiber type in a thermosetting resin matrix, said core having at least 50% fiber volume fraction, an operating capability in the range of about 90 to about 230 C, a modulus of elasticity in the range of about 22 to 37 Msi, a coefficient of thermal expansion in the range of about -0.7 to about 0 m/m/C and a tensile strength in the range of about 160 to about 240 Ksi.
- 25 13. A composite core as set forth in claim 12 wherein the reinforced fiber of the composite core is selected from the group consisting of carbon, Kevlar, basalt, glass, aramid, boron, liquid crystal fibers, high performance polyethylene and carbon nanofibers.
- 30 14. A composite core as set forth in claim 12 comprising a thermosetting resin having a neat resin fracture toughness at least about 0.87 INS-lb/in.
15. A composite core as set forth in claim 12 comprising a thermosetting resin having a tensile strength at least about 160 to about 240 Ksi.

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16. A composite core as set forth in claim 12 comprising a thermosetting resin having the ability to withstand ambient temperatures in the range of about -40 to about 90 C.
17. A composite core as set forth in claim 12 comprising a fiber/resin volume fraction in the range of about 50 to about 57%.
- 10 18. A composite core as set forth in claim 12 comprising a fiber/resin ratio in the range of about 62 to about 75% by weight.
19. A composite core as set forth in claim 12 comprising an operating temperature capability in the range of about 170 to about 220 C.
- 15 20. A composite core as set forth in Claim 12 comprising an ambient temperature capability in the range of about -40 to about 90C.
- 20 21. A composite core as set forth in claim 12 wherein the core comprises two or more longitudinally oriented and substantially continuous reinforced fiber types in a thermosetting resin matrix.
22. A composite core as set forth in claim 12 wherein said composite core comprises a hybridized concentric core having an inner carbon/epoxy layer and an outer glass fiber/epoxy layer.
- 25 23. A composite core for an aluminum conductor composite core reinforced cable comprising:
- 30 an inner core comprising an advanced composite; and
- an outer core comprising a low modulus composite.
24. A composite core as set forth in claim 23 wherein said inner and outer layers form a uniform concentric hybridized core.

25. A composite core as set forth in claim 23 having a total fiber volume fraction in the range of about 50 to about 57%.
- 5 26. A composite core as set forth in claim 23 having a total fiber/thermosetting resin ratio in the range of about 62 to about 75% by weight.
- 10 27. A composite core as set forth in claim 23 wherein the core comprises a tensile strength in the range of about 160 to about 240 Ksi, a modulus of elasticity in the range of about 7 to about 30 Msi, an operating temperature in the range of about 90 to about 230 C and a thermal expansion coefficient in the range of about 0 to about  $6 \times 10^{-6}$  m/m/C.
- 15 28. A composite core as set forth in claim 23 wherein the physical characteristics of said outer layer accommodates splicing.
- 20 29. A composite core as set forth in claim 23 wherein said composite core comprises a hybridized concentric core having an inner carbon/epoxy layer and an outer glass fiber/epoxy layer.
30. A composite core as set forth in claim 23 wherein the core comprises a tensile strength in the range of about 160 to about 240 Ksi.
- 25 31. A composite core as set forth in claim 23 wherein the core comprises a modulus of elasticity in the range of about 7 to about 30 Msi.
32. A composite core as set forth in claim 23 wherein the core comprises an operating temperature in the range of about 90 to about 230 C.
- 30 33. A composite core as set forth in claim 23 wherein the core comprises a thermal expansion coefficient in the range of about 0 to about  $6 \times 10^{-6}$  m/m/C.

34. A composite core for an aluminum conductor composite core reinforced cable comprising:
- 5 An inner core comprising a carbon/epoxy composite; and
- An outer core comprising a glass fiber/epoxy composite.
35. A composite core as set forth in claim 34 wherein said inner and outer layers form a uniform concentric hybridized core.
- 10 36. A composite core as set forth in claim 34 wherein said inner and outer layers form a segmented concentric core.
37. A composite core as set forth in claim 34 having a total fiber fraction volume in the range of about 50 to about 57%.
- 15 38. A composite core as set forth in claim 34 having a fiber/resin ratio in the range of about 62 to 75% by weight.
39. A composite core as set forth in claim 34 wherein the core comprises a tensile strength in the range of about 160 to about 240 Ksi, a modulus of elasticity in the range of about 7 to about 30 Msi, an operating temperature in the range of about 90 to about 230 C and a thermal expansion coefficient in the range of about 0 to about  $6 \times 10^{-6}$  m/m/C.
- 20 40. A composite core as set forth in claim 34 wherein the core comprises a tensile strength in the range of about 160 to about 240 Ksi.
41. A composite core as set forth in claim 34 wherein the core comprises a modulus of elasticity in the range of about 7 to about 30 Msi.
- 25 42. A composite core as set forth in claim 34 wherein the core comprises an operating temperature in the range of about 90 to about 230 C.
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43. A composite core as set forth in claim 34 wherein the core comprises a thermal expansion coefficient in the range of about 0 to about  $6 \times 10^{-6}$  m/m/C.
- 5 44. A composite core as set forth in claim 34 wherein the physical characteristics of said outer layer accommodates splicing.
45. An aluminum conductor composite core reinforced cable comprising:
- 10 a composite core having at least one longitudinally oriented and substantially continuous reinforced fiber type in a thermosetting resin matrix, said core having at least 50% fiber volume fraction, an operating temperature capability in the range of about 90 to about 230 C; a tensile strength in the range of about 160 to about 240 Ksi, a modulus of elasticity
- 15 in the range of about 7 to about 30 Msi and a thermal expansion coefficient in the range of about 0 to about  $6 \times 10^{-6}$  m/m/C; and
- at least one layer of aluminum conductor surrounding the composite core.
- 20 46. A cable as set forth in claim 45 wherein said at least one layer of aluminum surrounding the composite core comprises a plurality of trapezoidal shaped aluminum segments wrapped around the core.
47. A cable as set forth in claim 45 wherein a second layer of a plurality of
- 25 trapezoidal shaped aluminum segments is wrapped around the core.
48. A composite core as set forth in claim 45 wherein the composite core comprises two or more longitudinally oriented and substantially continuous reinforced fiber types.
- 30 49. A composite core as set forth in claim 45 wherein the composite core permits splicing.

50. A composite core as set forth in claim 45 comprising a fiber/resin volume fraction in the range of about 50 to about 57%.
51. A composite core as set forth in claim 45 comprising a fiber/resin ratio in the range of about 62 to about 75% by weight.
52. A cable of claim 45 wherein the reinforced fiber types of the composite core are selected from the group consisting of carbon, Kevlar, basalt, glass, aramid, boron, liquid crystal fibers, high performance polyethylene and carbon nanofibers.
53. A composite core as set forth in claim 45 wherein said composite core comprises a hybridized concentric core having an inner carbon/epoxy layer and an outer glass fiber/epoxy layer.
54. An aluminum conductor composite core reinforced cable comprising:
- a composite core having two or more longitudinally oriented and substantially continuous reinforced fiber types in a thermosetting resin matrix, said core having at least 50% fiber volume fraction and an operating capability in the range of about 90 to about 230 C; and
- at least one layer of aluminum conductor surrounding the composite core.
55. A composite core as set forth in claim 53 having a tensile strength in the range of about 160 to 240 Ksi.
56. A composite core as set forth in claim 53 having a modulus of elasticity in the range of about 7 to 30 Msi.
57. A composite core as set forth in claim 53 having a thermal expansion coefficient range of about 0 to  $6 \times 10^{-6}$  m/m/C.

58. A cable as set forth in claim 53 wherein said at least one layer of aluminum surrounding the composite core comprises a plurality of trapezoidal shaped aluminum segments wrapped around the core.
- 5 59. A cable as set forth in claim 53 wherein a second layer of a plurality of trapezoidal shaped aluminum segments is wrapped around the core.
60. A cable as set forth in claim 53 wherein the composite core permits splicing.
- 10 61. A composite core as set forth in claim 53 comprising a fiber/resin volume fraction in the range of about 50 to 57%.
62. A composite core as set forth in claim 53 comprising a fiber/resin ratio in the range of about 62 to 75% by weight.
- 15 63. A composite core as set forth in claim 53 wherein the fibers of the composite core are selected from the group consisting of carbon, Kevlar, basalt, glass, aramid, boron, liquid crystal fibers, high performance polyethylene and carbon nanofibers.
- 20 64. A composite core as set forth in claim 53 wherein said composite core comprises a hybridized concentric core having an inner carbon/epoxy layer and an outer glass fiber/epoxy layer.
- 25 65. An aluminum conductor composite core reinforced cable comprising:
- a carbon/epoxy inner core;
- a glassfiber/epoxy outer core; and
- 30 at least one layer of aluminum conductor surround the composite core.



66. A composite core as set forth in claim 64 wherein said inner core comprises a tensile strength at least about 370 Ksi, a tensile modulus of at least 20 Msi and tensile strain at least about 1.7%.
- 5 67. A composite core as set forth in claim 64 wherein said outer core comprises a tensile strength at least 298,103 psi and a tensile modulus at least  $11.2 \times 10^6$  psi.
- 10 68. A composite core as set forth in claim 64 wherein said outer core and said inner core form a uniform concentric hybridized core.
69. A composite core as set forth in claim 64 wherein said outer core and said inner core form a segmented concentric core.
- 15 70. A composite core as set forth in claim 64 wherein said outer core and said inner core have a total fiber volume fraction in the range of about 50 to about 57%.
- 20 71. A composite core as set forth in claim 64 wherein said outer core and said inner core have a total fiber/resin ratio in the range of 62 to 75% by weight.
- 25 72. A composite core as set forth in claim 64 wherein said core comprises a tensile strength in the range of about 160 to 240 Ksi, modulus of elasticity in the range of about 7 to 30 Msi, operating temperature in the range of about 90 to about 230 C and a thermal expansion coefficient in the range of about 0 to about  $6 \times 10^{-6}$  m/m/C.
- 30 73. A method of providing electrical power using an aluminum conductor composite core reinforced cable the steps comprising:
- using a cable having a composite core comprising at least one longitudinally oriented and substantially continuous reinforced fiber types in a thermosetting resin matrix said core having at least 50% by fiber volume fraction and an operating capability in the range of about 90 to

about 230 C surrounded by at least one layer of aluminum conductor  
surrounding the composite core; and

transmitting power across the composite cable.

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74. A method as set forth in claim 72 wherein said cable replaces at least a portion  
of existing cable.

75. A method as set forth in claim 72 wherein the composite core comprises a  
10 fiber/resin ratio in the range of about 62 to about 75% by weight.

76. A method as set forth in claim 72 wherein said cable comprises tensile  
strength in the range of about 160 to 240 Ksi, modulus of elasticity in the  
range of about 7 to 30 Msi, operating temperature in the range of about 90 to  
15 about 230 C and a thermal expansion coefficient in the range of about 0 to  
about  $6 \times 10^{-6}$  m/m/C.

77. A method as set forth in claim 72 wherein said cable comprises an ambient  
temperature range of about -40C to about 90 C.

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78. Method of processing a composite core comprising the steps of:

providing a predetermined number of fiber tows;

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guiding the fiber tows through a wet-out tank filled with resin;

using a B-stage oven and a plurality of bushings spaced apart to shape and  
compress said fiber tows; and

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curing the composite core member;

79. A method as set forth in claim 77 wherein said guide is a plate having a  
plurality of passageways wherein the orientation of passageways is determined  
by the desired cross section configuration of the composite core.

80. A method as set forth in claim 77 wherein the number and type of fiber tows is determined to meet physical characteristics in the end composite core including a tensile strength in the range of 160 to 240 Ksi, a modulus of elasticity in the range of about 7 to about 30 Msi, an operating temperature in the range of about 90 to about 230 C and a thermal expansion coefficient in the range of about 0 to about  $6 \times 10^{-6}$  m/m/C.
81. A method as set forth in claim 77 wherein the step of guiding the fiber tows through a wet-out tank filled with resin further comprises a pre-heating step prior to wet-out to evaporate moisture in the fiber tows.
82. A method as set forth in claim 77 wherein the wet out tank filled with resin comprises a device to aid in wetting the fibers.
83. A method as set forth in claim 77 wherein the wet out tank filled with resin comprises a series of wipers to remove excess resin from the fibers.
84. A method as set forth in claim 77 wherein the step of shaping and compressing the fiber tows further comprises:
- guiding the fiber tows into a first B-stage temperature oven;
- guiding the fiber tows into a second B-stage temperature oven comprising a series of bushings wherein each bushing in the series comprises a plurality of passageways;
- guiding the fiber tows through the consecutive series of bushings and passageways; and
- using the bushings to form the composite core.
85. A method as set forth in claim 77 wherein the size of at least a portion of the passageways diminishes with consecutive bushings.

86. A method as set forth in claim 77 wherein at least a portion of the position of the passageways changes with consecutive bushings.
- 5 87. A method as set forth in claim 77 wherein the first B-stage temperature oven is in the range of about 200 to about 250 F.
88. A method as set forth in claim 77 wherein the second B-stage temperature oven is in the range of about 200 to about 250 F.
- 10 89. A method as set forth in claim 77 wherein the step of curing the composite core further comprises:
- 15 guiding the composite core from the second B-stage temperature oven to a curing oven wherein the curing oven temperature is in the range of about 330 to about 370 F;
- 20 guiding the composite core from the curing oven to a cooling zone wherein the cooling zone is in the range of about 30 to about 100 F;
- 25 guiding the composite core from the cooling zone to a post-cure oven wherein the temperature of the post-cure oven is in the range of about 330 to about 370 F; and
- 30 90. A method as set forth in claim 77 wherein the fibers of the composite core are selected from the group consisting of carbon, Kevlar, basalt, glass, aramid, boron, liquid crystal fibers, high performance polyethylene and carbon nanofibers.

91. A method as set forth in claim 77 wherein the method of processing comprises processing speeds in the range of about 9 ft/min to about 50 ft/min.
92. A method of improving the efficiency of an electrical power distribution system the steps comprising:
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- forming an aluminum conductor composite core reinforced cable comprising a composite core having at least one longitudinally oriented and substantially continuous reinforced fiber types in a thermosetting resin matrix said core having at least 50% fiber volume fraction and an operating capability in the range of about 90 to about 230 C surrounded by at least one layer of aluminum conductor; and
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- replacing at least a portion of existing distribution lines with said cable.
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93. A method as set forth in claim 91 wherein said composite core comprises a fiber/resin ratio in the range of 62 to 75% by weight.
94. A method as set forth in claim 91 wherein said composite core comprises a fiber volume fraction in the range of about 50 to about 57%.
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95. A method as set forth in claim 91 wherein said composite core comprises a hybridized concentric core having an inner carbon/epoxy layer and an outer glass fiber/epoxy layer.
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96. A composite core for an aluminum conductor composite core reinforced cable comprising:
- a segmented inner core comprising advanced composite; and
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- a segmented outer core comprising low modulus composite.
97. A composite core as set forth in claim 95 wherein the total fiber fraction is in the range of about 50 to about 57%.

98. A composite core as set forth in claim 95 wherein the total fiber/resin ratio is in the range of about 62 to 75% by weight.
- 5 99. A composite core as set forth in claim 95 wherein the core comprises a tensile strength in the range of about 160 to about 240 Ksi, modulus of elasticity in the range of about 7 to about 30 Msi, operating temperature in the range of about 90 to about 230 C and a thermal expansion coefficient in the range of about 0 to about  $6 \times 10^{-6}$  m/m/C.
- 10 100. A composite core as set forth in claim 95 wherein the physical characteristics of said outer layer accommodates splicing.
- 15 101. A composite core as set forth in claim 95 wherein the segments are formed separately.
- 20 102. A composite core as set forth in claim 95 wherein said composite core comprises a segmented concentric core having an inner carbon/epoxy layer and an outer glass fiber/epoxy layer.

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